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Procedia Economics and Finance 10 (2014) 227 – 236

Procedia Economics and Finance

www.elsevier.com/locate/procedia

7th International Conference on Applied Statistics

Revisiting the relationship between unemployment rates and shadow economy. A Toda-Yamamoto approach for the case of Romania

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Abstract

Shadow economy(SE) is a controversial topic that has aroused the interest of the specialists from the 60's, when the phenomenon took a great extent. Formed in the literature under various names, the shadow economy exists in a more or less extent in all countries, regardless of their level of development, enjoying an enduring existence, although as area of research is a new "young" area.

The paper aims to investigate the relationship between the size of the shadow economy (SE) and the registered and ILO unemployment rates for the case of Romanian data using Toda-Yamamoto approach for quarterly data covering the period 2000-2010.

The size of the Romanian shadow economy based on the currency demand approach was estimated using multivariate cointegration and vector error correction models (VECM) in order to investigate whether a long-run equilibrium relationship exists between currency demand and its determinants.

In order to investigate the relationship between the unemployment rates and the size of the shadow economy for the case of Romania we use an innovative econometric methodology to study the direction of causality between the two variables, namely Toda and Yamamoto (1995).

According to Giles and Tedds(2002), two opposing forces determine the relationship between unemployment and the informal economy. On the one hand, an increase in the unemployment rate may involve a decrease in the informal economy because it is positively related to the growth rate of GDP and eventually negatively correlated with unemployment (Okun's law). On the other hand, increase in unemployment leads to an increase in people working in the informal economy because they have more time for such activities.

Dell'Anno and Solomon (2007) stated that there is a positive relationship in the short-run between unemployment rate and U.S. shadow economy for the period 1970-2004. Using SVAR analysis, they investigate the response of the shadow economy to an aggregate supply shock (impact of the shadow economy to a temporary shock in unemployment). The empirical results show that in the short-run, a positive aggregate supply shock causes the shadow economy to rise by about 8% above the baseline.

According to the Toda-Yamamoto causality test results, there is strong evidence of causality running from the registered and

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Selection and peer-review under responsibility of the Department of Statistics and Econometrics, Bucharest University of Economic Studies.
doi:10.1016/S2212-5671(14)00297-4

ILO unemployment rates to the shadow economy when a sufficiently high lag order is selected.

Selection and peer-review under responsibility of the Department of Statistics and Econometrics, Bucharest University of Economic Studies.

Keywords: shadow economy, currency demand approach, unemployment rates, Toda-Yamamoto approach

1. Introduction

The relationship between the shadow economy (SE) and the level of unemployment is one of major interest. People work in the shadow economy because of the increased cost that firms in the formal sector have to pay to hire a worker. The increased cost comes from the tax burden and government regulations on economic activities. In discussing the growth of the shadow economy, the empirical evidence suggests two important factors: (a) reduction in official working hours, (b) the influence of the unemployment rate (UR).

Enste(2003) points out that the reduction of the number of working hours below worker's preferences raises the quantity of hours worked in the shadow economy. Early retirement also increases the quantity of hours worked in the shadow economy.

In Italy, Bertola and Garibaldi(2003) present the case that an increase in payroll taxation can have effect on the supply of labour and the size of the shadow economy. An increase in tax and social security burdens not only reduces official employment but tends to increase the shadow labour force. This is because an increase in payroll tax can influence the decision to participate in official employment.

Also, Boeri and Garibaldi(2002) show a strong positive correlation between average unemployment rate and average shadow employment across 20 Italian regions during the period 1995-1999.

Dell'Anno and Solomon(2007) find a positive relationship between unemployment rate and shadow economy using a SVAR analysis, showing that a positive aggregate supply shock will cause in increase in the shadow economy by about 8% above the baseline.

The paper analyzes the causal relationship between shadow economy and unemployment rates using Toda-Yamamoto approach.

2. Data and methodology

2.1.Data issues

The data used in the research covers the period 2000:Q1- 2010Q2. The variables used are as follows: the size of the Romanian shadow economy expressed as % of official GDP (SE) obtained by currency demand approach; ILO unemployment rate (ILO_UR) and registered unemployment rate (R_UR). The unemployment rates were seasonally by means of tramo seats method. The main source of the data for unemployment rates is the National Institute of Statistics (Tempo database) and the National Bank of Romania.

2.2. Methodology

The size of Romanian shadow economy was estimated using one of the most commonly used indirect methods proposed by Cagan and Tanzi's that assumes that shadow (or hidden) transactions are undertaken in the form of cash payments, so as to leave no observable traces for the authorities. An increase in the size of the shadow economy will therefore increase the demand for currency. To isolate the resulting „excess" demand for currency, an equation for currency demand is econometrically estimated over time:

$$C_0 = A \cdot (1+\Theta)^{\alpha} \cdot Y_0^{\beta} \cdot \exp(-\gamma i) \quad (1)$$

where: C_0 represents the observed cash, Θ represents the variable that gives incentives to make hidden transactions. This is the key variable of all currency models and it can be approximated using government consumption normalized by GDP, tax rates (direct and indirect taxes), tax revenues to GDP. An increase in Θ is expected to have a positive impact on currency demand, since agents will have more incentives to go to the shadow sector, demanding more currency for their transactions, Y_0 represents the registered GDP, but also it can be used GDP per capita, consumption per capita, i represents the interest rate, α, β, γ, A represents the parameters.

Estimating equation (1), it will be obtained $\hat{C}$.Setting the incentive variable Θ equal to zero, and leaving the coefficients of the other variables unchanged, we obtain $\tilde{C}$.The difference between $\hat{C}$ and $\tilde{C}$ is the amount of extra currency. In other words, the difference measures the amount of illegal money in the economy. Forth more, assuming that the velocity of money is the same in both official and shadow sector†, we can obtain an estimate of the size of shadow economy multiplying illegal money ($EC = \hat{C} - \tilde{C}$) by the velocity of money ($v = \frac{Y}{C}$).

The size of the Romanian shadow economy based on the currency demand approach was estimated using multivariate cointegration and vector error correction models (VECM) in order to investigate whether a long-run equilibrium relationship exists between currency demand and its determinants.

In order to estimate the amount of currency demand we have specified several models(including the classical model of Tanzi) in order to identify the model that capture the long-run relationship of the explanatory variables on currency demand.

The demand for currency is driven by various explanatory variables: real GDP, real GDP per capita, real disposable income, total tax revenues, real interest rates, ratio of wages and salaries, ratio of final government consumption expenditure, inflation rate, ratio of social benefits, ratio of private consumption expenditure.

It is assumed that a rise in the tax burden variable will lead to an increase in the size of the unrecorded economic activities which requires a higher level of demand for currency.

Quarterly time-series data covering the period 2000-2010 were used. All series were expressed in logarithmic form. The main sources used to collect the data are: Eurostat, National Bank of Romania and National Institute of Statistics.

As a preliminary step, we carried out tests of non-stationarity for each series. Furthermore, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)) tests were employed in order to identify each variable's integration level. Both tests were consistent with the hypothesis that the variables are level-unstationary but first difference stationary.

Since it has been determined that the variables under examination are integrated of order 1 then the Pantula principle and the Johansen and Juselius cointegration test were be performed. The tests suggest at least one cointegrating vector exists for each model considered, meaning that there is a long-run equilibrium relationship between the variables of the model.

Given the non-stationarity of our series, traditional estimation methods are ruled out and we must then estimate a VAR model in which we shall include a mechanism of error correction model (ECM). A detailed description of estimating the size of Romanian shadow economy using currency demand approach based on vector error correction models is provided in Davidescu and Dobre(2013).

After we estimate the size of Romanian shadow economy, we investigate the nature of the relationship between the two variables using Toda-Yamamoto approach.

Toda and Yamamoto (1995) causality test is applied in level VARs irrespective of whether the variables are integrated, cointegrated, or not. Toda and Yamamoto (1995) argue that F-statistic used to test for traditional Granger causality may not be valid as the test does not have a standard distribution when the time series data integrated or cointegrated.

The Toda-Yamamoto procedure basically involves estimation of an augmented VAR (k +$d$max) model, where k is the optimal lag length in the original VAR system and $d$max is maximal order of integration of the variables in the

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† This assumption has been criticized and, as Ahumada et al. (2007) claim, even if the velocity is the same, previous works that find $\beta \neq 1$ (i.e. income elasticity different from 1) are incorrect. Therefore, they propose an alternative way of correcting the estimates.

VAR system.

The Toda-Yamamoto causality test applies a modified Wald (MWALD) test statistic to test zero restrictions on the parameters of the original VAR (*k*) model. The test has an asymptotic (chi-square) distribution with *k* degrees of freedom.

The test essentially involves two stages. The first stage determines the optimal lag length (*k*) and the maximum order of integration (*d*) of the variables in the system. The lag length, *k* is obtained in the process of the VAR in levels among the variables in the system by using different lag length criterion such as AIC or SBC. The unit root testing procedure, such as Dickey-Fuller(1981) ADF and Phillips-Perron(1985) tests may be used to identify the order of integration, *d*.

The second stage uses the modified Wald procedure to test the VAR (*k*) model for causality. The optimal lag length is equal to *p*= [*k*+*d*(max)]. In the case of a bivariate (*Y*, *X*) relationship, Toda and Yamamoto(1995) causality test is represented as follows (Esso, 2010):

$$Y_t = a_0 + \sum_{i=1}^{k} b_{1i} \cdot Y_{t-i} + \sum_{i=k+1}^{k+d_{\max}} b_{2i} \cdot Y_{t-i} + \sum_{i=1}^{k} c_{1i} \cdot X_{t-i} + \sum_{i=k+1}^{k+d_{\max}} c_{2i} \cdot X_{t-i} + e_{1t} \quad (2)$$

$$X_t = d_0 + \sum_{i=1}^{k} e_{1i} \cdot X_{t-i} + \sum_{i=k+1}^{k+d_{\max}} e_{2i} \cdot X_{t-i} + \sum_{i=1}^{k} f_{1i} \cdot Y_{t-i} + \sum_{i=k+1}^{k+d_{\max}} f_{2i} \cdot Y_{t-i} + e_{2t} \quad (3)$$

where: $Y_t = SE_t$, $X_t = UR_t$, e_{1t}, e_{2t} are the residuals of the models.

The Wald tests were then applied to the first k coefficients matrices using the standard χ^2 statistics (Duasa(2007)).

Let $c_1 = vec(c_{11}, c_{12}, ..., c_{1k})$ be the vector of the first k VAR coefficients.

The null hypothesis that *X* does not cause *Y* is constructed as follows: $H_0 : c_{1i} = 0$, $i = 1,...,k$.

Similarly the second null hypothesis that *Y* does not cause *X* is formulated as follows: $H_0 : f_{1i} = 0$, $i = 1,...,k$.

The system given by equations (4)-(5) is estimated using the Seemingly Unrelated Regression technique (Rambaldi and Doran(1996)). A Wald test is then carried out to test the hypothesis. The computed Wald-statistic has an asymptotic chi-square distribution with k degrees of freedom.

3.Empirical results

3.1. Estimating the size of the shadow economy

In order to estimate the size of the shadow economy, we have identified the best model as the model in which the coefficients for output, tax burden and wages have a positive long-run effect, while interest rate take the pressure off on currency demand. Thus, the model M_1 is considered to be the best model.

This implies that an increase in the tax rate is likely to motivate individuals to participate in the underground economy in an attempt to increase their income. The coefficient on interest rates is negative as expected reflecting the increasing opportunity cost in holding currency balances when interest rates are rising. All coefficients are strongly statistically significant.

The significance of the error correction term (ECT) shows causality in at least one direction. The lagged error term (EC_{t-1}) in our results is negative and highly significant. The error correction term for model M_1 - as -1.22 (0.20) indicates a high rate of convergence to equilibrium, which implies that deviation from the long-term equilibrium is corrected by 122% over each quarter. The coefficient of the error correction term is significant at 1% level and greater than unity implying a high speed of adjustment towards equilibrium.

After estimating the vector error correction model (VECM), the size of the shadow economy is computed using the difference between the amount of currency demanded in an economy and the amount that would be demanded if

the tax variable is set equal to zero. This difference gives the amount of extra currency in the economy. Asuming equal velocity in both economies, we compute the size of the shadow economy multiplying the amount of extra currency with the velocity of money.

The empirical results of currency demand approach based on VECM models emphasizes that there is a general downward trend in the size of the shadow economy as % of official GDP for the period 2000-2010 with an highlight on two low periods, 2003Q1 and 2008Q4.

Thus, the size of the shadow economy as % of official GDP measures approximately 36.6% in 2000Q1 and follows a downward trend after registering the value of 31% by 2008. For the past few quarters, there is a slightly upward trend in the size of Romanian shadow economy. The results are consistent with studies by Schneider (2007) and Albu (2007, 2010, 2011) which show a mainly downward trend of informal economy in Romania.

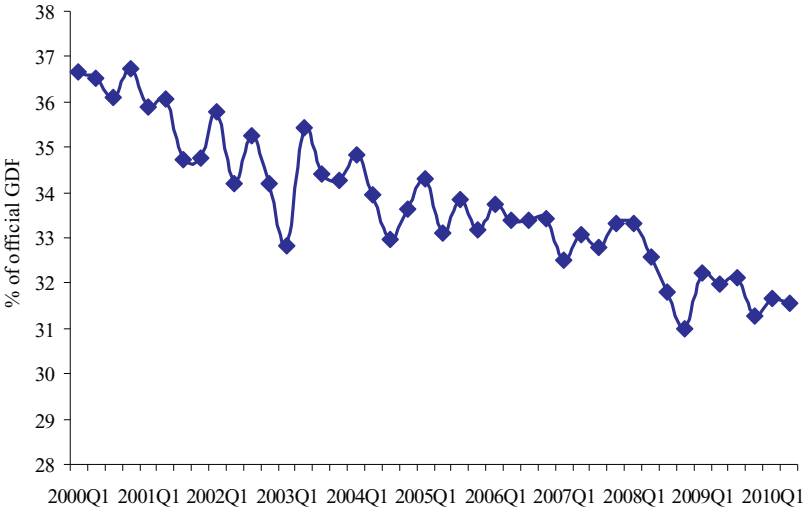


Fig.1. The size of Romanian shadow economy as % of official GDP ‡

3.2. The relationship between unemployment rates and the Romanian shadow economy

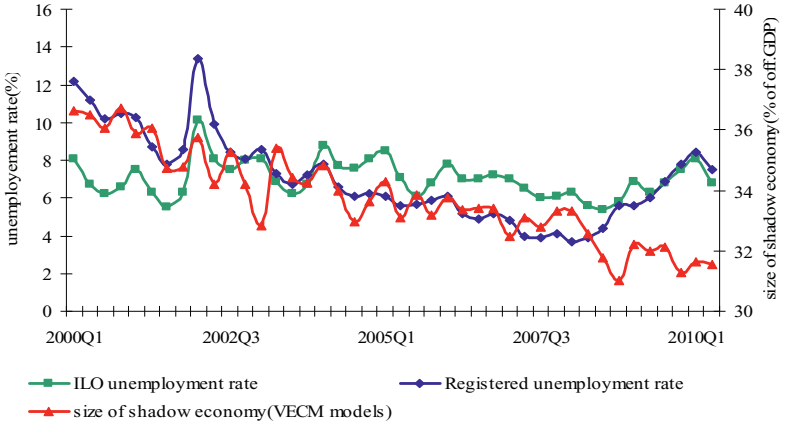
According to Giles and Tedds (2002), two opposing forces determine the relationship between unemployment and the informal economy. On the one hand, an increase in the unemployment rate may involve a decrease in the informal economy because it is positively related to the growth rate of GDP and eventually negatively correlated with unemployment (Okun's law). On the other hand, increase in unemployment leads to an increase in people working in the informal economy because they have more time for such activities.

Dell'Anno and Solomon (2007) stated that there is a positive relationship in the short-run between unemployment rate and U.S. shadow economy for the period 1970-2004. Using SVAR analysis, they investigate the response of the shadow economy to an aggregate supply shock (impact of the shadow economy to a temporary shock in unemployment). The empirical results show that in the short-run, a positive aggregate supply shock causes

‡ It is important to note that because of its undetectable nature and character, it is nearly impossible to measure precisely the size of economic activities taking place in the informal economy of any country in the world, whether developed or less developed. Given this, any theoretical or empirical inference derived from these results should always be regarded as an approximation. In the face of these difficulties, the results drawn from these estimates should be interpreted with due reserve, given the limitations of the methods.

the shadow economy to rise by about 8% above the baseline.

Regarding the Romanian unemployment data, there are two measures available for unemployed persons: the first is the registered unemployment rate, who is calculated by National Agency for Employment (NAE) and based on statements of people who pass by employment agencies and said that they are unemployed and the ILO unemployment rate, who is published quarterly by the National Institute of Statistics and is based on labour force survey (LFS).The figures are far from identical.



Source: Size of the shadow economy (% of official GDP); Tempo database, National Institute of Statistics, Monthly Bulletins 2000-2010, National Bank of Romania.

Fig.2.Shadow economy vs. unemployment rates in Romania

The graphical evolution of the shadow economy versus unemployment rates reveal the existence of a positive relationship between variables, low for the case of ILO unemployment rate, quantified by a value of about 0.22 of correlation coefficient and strong for the case of registered unemployment rate, quantified by a value of 0.67 of correlation coefficient.

3.2.1. Revisiting the relationship between shadow economy and unemployment rates. A Toda-Yamamoto approach

The results of causality test are reported in three steps. First we test for the order of integration of the variables; second, we find out the optimum lag structure using Akaike Information Criterion (AIC) and Final Prediction Error (FPE). Lastly, we conduct the Wald test to analyse non-causality between shadow economy (SE) and registered unemployment rate (R_UR) on the one hand and between shadow economy (SE) and ILO unemployment rate (ILO_UR) on the other hand.

Prior to Toda-Yamamoto non-causality test, the order of integration of the variables is initially determined using the ADF and PP unit root tests. The results are given in table 1. The results reveal that the variables are I(1), as the null hypothesis of a unit root is not rejected for the level series but rejected at the first differenced series. Therefore, the maximum order of integration in the VAR system, $d_{\max} = 1$.

Given that both series were found to be integrated of order one, we specify the model by determining the optimal lag length of all level variables in the model. The optimum lag length (k) chosen by AIC and FPE[§] is found

[§] The maximal lag length was set to 7.

to be 5 for the case of registered unemployment rate and 6 for the case of ILO unemployment rate. Since $d_{\max} = 1$ we must estimate a VAR (6) for registered unemployment rate model and a VAR (7) for ILO unemployment rate model.

Table 1. ADF and PP Tests for Unit Root

		Shadow economy(SE)			Registered unemployment rate(R_UR)			ILO unemployment rate(ILO_UR)		
		T&C	C	None	T&C	C	None	T&C	C	None
Level	ADF	-6.29*	-1.05	-3.28	0.24	-1.58	-0.73	-3.03	-2.70	-0.36
	lag	(0)	(6)	(6)	(4)	(4)	(4)	(1)	(0)	(0)
	PP	-6.29*	-1.74	-1.38	-0.68	-2.13	-1.34	-2.88	-2.70	-0.32
	lag	(1)	(3)	(1)	(3)	(1)	(1)	(1)	(0)	(5)
First diff.	ADF	-10.63*	-10.74*	-10.45*	-3.51***	-2.83***	-2.89*	-6.13*	-6.22*	-6.30*
	lag	(0)	(0)	(0)	(3)	(3)	(3)	(0)	(0)	(0)
	PP	-11.34*	-9.90*	-8.86*	-7.14*	-6.17*	-6.19*	-6.59*	-6.72*	-6.85*
	lag	(3)	(2)	(3)	(7)	(1)	(1)	(6)	(6)	(6)

Note:
T&C represents the most general model with a drift and trend; C is the model with a drift and without trend; None is the most restricted model without a drift and trend. Numbers in brackets are lag lengths used in ADF test (as determined by SCH set to maximum 12) to remove serial correlation in the residuals. When using PP test, numbers in brackets represent Newey-West Bandwith (as determined by Bartlett-Kernel). Both in ADF and PP tests, unit root tests were performed from the most general to the least specific model by eliminating trend and intercept across the. *, ** and *** denote rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Tests for unit roots have been carried out in E-VIEWS 6.0.

Before examining the causality test, a series of diagnostic test is implemented to assure that the underlying assumption holds (Duasa, 2007). The results of Breush-Godfrey Serial Correlation LM and White tests indicate that all the VAR models have no problem of serial correlation and heteroscedasticity.
The Toda-Yamamoto test involves the addition of one extra lag of each of the variables to each equation and the use of the Wald test is to see if the coefficients of the lagged "other" variables (***excluding the additional one***) are jointly zero in the equation (Duasa, 2007).
Employing the seemingly unrelated regression (SUR) framework, we estimated a VAR(6) for registered unemployment rate as follows:

$$x_t = A_0 + A_1 \cdot x_{t-1} + A_2 \cdot x_{t-2} + A_3 \cdot x_{t-3} + A_4 \cdot x_{t-4} + A_5 \cdot x_{t-5} + A_6 \cdot x_{t-6} + e_t \quad (4)$$

$$\begin{bmatrix} SE_t \\ R\_UR_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11}^{(1)} & a_{12}^{(1)} \\ a_{21}^{(1)} & a_{22}^{(1)} \end{bmatrix} \cdot \begin{bmatrix} SE_{t-1} \\ R\_UR_{t-1} \end{bmatrix} + \ldots \begin{bmatrix} a_{11}^{(6)} & a_{12}^{(6)} \\ a_{21}^{(6)} & a_{22}^{(6)} \end{bmatrix} \cdot \begin{bmatrix} SE_{t-6} \\ R\_UR_{t-6} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \quad (5)$$

where:

$$E(e_t) = \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = 0 \text{ and } E(e_t e_t^{'}) = \Sigma$$

To test that R_UR does not Granger cause SE, we estimate the VAR (6) model and test that $R\_UR_{t-1},\ldots R\_UR_{t-5}$ does not appear in SE equation.

Thus the null hypothesis is $H_0 : a_{12}^{(1)} = a_{12}^{(2)} = a_{12}^{(3)} = a_{12}^{(4)} = a_{12}^{(5)} = 0$ where $a_{12}^{(i)}$ are the coefficients of R_UR_{t-i}, $i = 1,\ldots,5$ in the first equation of the system.

The existence of causality from registered unemployment rate to shadow economy can be established

through rejecting the above null hypothesis which requires finding the significance of the MWald statistic for the group of the lagged independent variables identified above.
For the ILO unemployment rate and shadow economy we will estimate using the SUR framework a VAR(7) model:

$$\begin{bmatrix} SE_t \\ ILO\_UR_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11}^{(1)} & a_{12}^{(1)} \\ a_{21}^{(1)} & a_{22}^{(1)} \end{bmatrix} \cdot \begin{bmatrix} SE_{t-1} \\ ILO\_UR_{t-1} \end{bmatrix} + ... \begin{bmatrix} a_{11}^{(7)} & a_{12}^{(7)} \\ a_{21}^{(7)} & a_{22}^{(7)} \end{bmatrix} \cdot \begin{bmatrix} SE_{t-7} \\ ILO\_UR_{t-7} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \quad (6)$$

To test that ILO_UR does not Granger cause SE, we estimate the VAR (7) model and test that $ILO\_UR_{t-1},...,ILO\_UR_{t-6}$ does not appear in SE equation.

Thus the null hypothesis is $H_0 : a_{12}^{(1)} = a_{12}^{(2)} = a_{12}^{(3)} = ... = a_{12}^{(6)} = 0$ where $a_{12}^{(i)}$ are the coefficients of ILO_UR_{t-i}, $i = 1,6$ in the first equation of the system.

The existence of causality from ILO unemployment rate to shadow economy can be established through rejecting the above null hypothesis which requires finding the significance of the MWald statistic for the group of the lagged independent variables identified above.
Although, the order of integration of each variable was proved to be $d_{\max} = 1$, we tested the causality Toda-Yamamoto also for $d_{\max} = 2$, since in most of the cases, the order of the integration of macroeconomic variables are at most two. The result for $d_{\max} = 1$ and $d_{\max} = 2$ are presented in tables 2 and 3 respectively.

Table 2.The results of the Toda-Yamamoto causality test for $d_{\max} = 1$

Null hypothesis	p	MWald statistics	p-values	Decision
$k = 5$				
H_0 : R_UR does not Granger cause SE	6	16.30	0.006*	Reject H_0
H_0 : SE does not Granger cause R_UR	6	7.53	0.183	Do not reject H_0
$k = 6$				
H_0 : ILO_UR does not Granger cause SE	7	21.87	0.001*	Reject H_0
H_0 : SE does not Granger cause ILO_UR	7	8.78	0.185	Do not reject H_0

*, ** indicates rejection of the null at the 1% level, respectively 5% level.

Table 3.The results of the Toda-Yamamoto causality test for $d_{\max} = 2$

Null hypothesis	p	MWald statistics	p-values	Decision[a]
$k = 5$				
H_0 : R_UR does not Granger cause SE	7	24.20	0.000*	Reject H_0
H_0 : SE does not Granger cause R_UR	7	12.05	0.03**	Reject H_0
$k = 6$				
H_0 : ILO_UR does not Granger cause SE	8	21.72	0.001*	Reject H_0
H_0 : SE does not Granger cause ILO_UR	8	6.05	0.417	Do not reject H_0

*, ** indicates rejection of the null at the 1% level, respectively 5% level.

According to the Toda-Yamamoto causality test results shown in Table 2, there is strong evidence of causality running from the registered and ILO unemployment rate to the SE at the 1 percent level of significance, rejecting the

null hypothesis of non-causality. The results from Table 3 suggest similar unidirectional causality that runs from registered and ILO unemployment rate to the size of the shadow economy in the case of $d_{\max} = 2$. Finally, the empirical results support the existence of a unidirectional causality that runs from unemployment rate (registered or ILO) to shadow economy, when a sufficiently high lag order is selected.

4. Conclusions

In this paper, we investigate the relationship between unemployment rates and the size of the Romanian shadow economy using Toda-Yamamoto approach. The Romanian shadow economy as % of official GDP is estimated using the currency demand approach based on vector error correction models, and its size is decreasing over the analysed period, from 36.5% at the end of 2000 to about 31.5% of real GDP at the middle of 2010.

The dynamic relationship between shadow economy as % of official GDP obtained through VECM models and unemployment rates for the case of Romania has been investigated using quarterly time series data from 2000-2010.

We have used Toda-Yamamoto (1995) causality test in order to test the causal relationship between registered unemployment rate and Romanian shadow economy. The evidence, based on MWald-tests, generally supports the existence of the unidirectional causality between unemployment rate (registered and ILO) and shadow economy. The empirical results support the existence of a unidirectional causality that runs from unemployment rates to shadow economy, when a sufficiently high lag order is selected.

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